Design and Verification of an Optimized Reconfigurable Intelligent Surface

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Subject Area
Wireless Communications

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Introduction: Reconfigurable Intelligent Surfaces (RISs) are a relatively new concept, widely anticipated to be pivotal in future wireless systems. They enhance coverage and capacity by intelligently reflecting otherwise lost signals back into the system. One approach to constructing such an RIS involves arranging numerous antennas on a surface, like in a reflectarray, and steering the reflected signals by adjusting each antenna's loading reactance. A preexisting optimization procedure provides the provably optimal reactive loads for a particular RIS scenario. Previously, this had only been verified via simulation. This project aims at designing a small RIS for an operating frequency of 3.55 GHz, the center of the newly adopted 5G band «n78», to verify the optimization procedure and the RIS operation in practice.

Approach: First, several varactor diodes are characterized around the frequency of interest, to obtain their complete capacitance vs. reverse bias voltage behavior. As shown in Fig. 1, these diodes exhibit negligible variation across individual measurements, and the results closely align with the limited information on the datasheet. Second, a 14-element dipole reflectarray antenna is designed, with each antenna element centrally loaded with a varactor diode. To ensure future scalability, a 96-channel DAC is utilized to generate the reverse bias voltages, delivered to each dipole element via its own small bias network. Finally, the performance of the fully assembled RIS is evaluated at various angles using a dedicated measurement setup, as shown in Fig. 3. Time gating is used to mitigate environmental interference and ignore the direct path between the measurement antennas.

Result: The realized RIS works as intended and its effectiveness is verified as shown in Fig. 2. It is noteworthy that even such a small RIS can have a considerable effect at angles far from the specular reflection. Furthermore, the convenient adjustability of the loading reactances allows for precise fine-tuning, helping to bridge any gaps between simulation and real-world outcomes.

Fig. 1: Capacitance of the measured varactor diodes as a function of reverse bias voltage, compared to the datasheet.

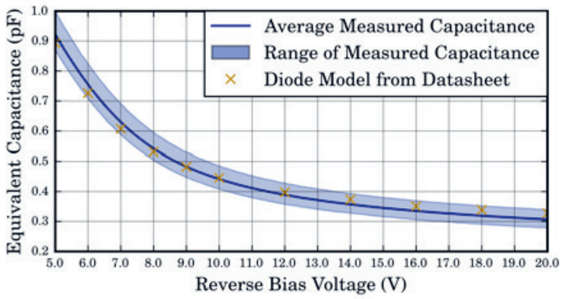

Fig. 2: Comparison of the RIS performance between optimized and switched off settings.
Own presentment

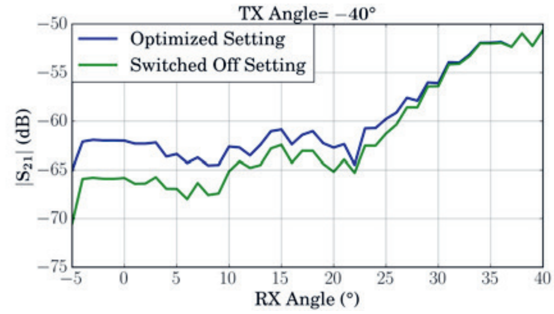

Fig. 3: Measurement setup to characterize the RIS, using two horn antennas and a VNA.
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